COMPLETE APPLICATION OF PROFILED STEEL SHEETING DRY BOARD SYSTEM AS SCHOOL CLASSROOM MODULES

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ABSTRACT: This paper describes the application of Profiled Steel Sheet Dry Board (PSSDB) system as innovative lightweight composite school classroom modules. The structural composite panel system consists of profiled steel sheet attached to the dry board via mechanical self drilling and self tapping screws. Compared to traditional building systems and materials, the PSSDB system eliminates the used of conventional timber formworks, columns and roof trusses in buildings. Besides, the proposed system has many advantages such as it is lightweight, making construction less labour-orientated, shorter construction time, materials optimisation, and provides better finished products. The proposed panel system falls under the Industrialised Building System (IBS) category since all the structural panel components are manufactured in a factory, transported and assembled into a structure or building with minimal additional site work. The system was successfully implemented in two school classroom modules at Sekolah Kebangsaan Telok Mas, Melaka, Malaysia.

Keywords: Profiled steel sheet, Dry board, Industrialised building system, School classroom modules.

1. INTRODUCTION

In 2007, the government of Malaysia has announced an additional allocation of RM 2.6 billion for the development of education in rural areas (Jamdi, 2007). This is a boost to the grand Education Development Master Plan 2006-2010 (KPM, 2006) which has also proposed to build 5,138 classrooms under the Upgrading Rural Education Development programme in Sabah and Sarawak. The Minister of Education has also reiterated that schools which have limited space and are under enrolled in rural areas will use the cabin concept for the construction of their new computer labs (Habibah, 2007). In fact, the Ministry of Education (MOE) has already embarked on new rural school modules based on the cabin concept that has recently been tendered out for bidding by contractors for the state of Sabah.

As part of the initiative related to the above needs, an Industrialised Building System (IBS), namely the Profiled Steel Sheeting Dry Board System (PSSDB) developed at Universiti Kebangsaan Malaysia has been utilised in a pilot project to build two temporary classrooms for Sekolah Kebangsaan Telok Mas, Melaka. This paper will discuss the salient features of the project.

The PSSDB system is a lightweight composite system consisting of profiled steel sheet connected to dry boards by self drilling and self tapping screws. The screws play an important role in transferring the shear force between the dry board and profiled steel sheeting, thus resulting in composite action between the two components. The performance of a connection depends on the type of screw, profiled steel sheet and dry board used, and also on the spacing of the screws which together determine the degree of composite action and the stiffness of the structural composite system. The panel results in a strong and efficient composite structural system which can be assembled to virtually numerous sizes and strength combinations. The original concept of PSSDB system was first introduced by Wright and Evans (1986) as a replacement to existing timber joist floor. Figure 1 shows the typical composition of PSSDB system.

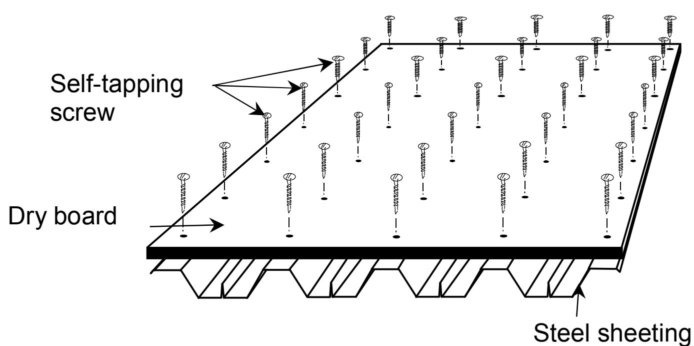


Figure 1. Typical PSSDB system

The study of the behaviour of PSSDB floor, wall and roof system was done by Wan Badaruzzaman (1994), Wan Badaruzzaman et al. (1996), Wan Badaruzzaman and Wright (1998), Ahmed (1999), Ahmed et al. (2000), Benayoune et al. (2000), Ahmed et al. (2001), Akhand (2001), Wan Badaruzzaman et al. (2003), Shodiq (2004), Ahmed and Wan Badaruzzaman (2003, 2005), Hamzah (2005), Rahmadi (2005), Awang and Wan Badaruzzaman (2007), and Awang (2008).

The research works conducted show that the system can be used practically as a flooring system (as it was originally intended) as well as load bearing wall and roof systems. Various commercial projects have already implemented the system such as at the 5-star Hyatt Hotel in Kota Kinabalu, Sabah in 1997, UiTM

Tower, Shah Alam in 1997, UKM Bangunan Wawasan, exhibition gallery and solar house at UKM as well as a private house in Bangi (Wan Badaruzzaman et al., 2001).

2. THE ADVANTAGES OF THE SYSTEM

The PSSDB system has many advantages compared to traditional systems. According to Wan Badaruzzaman and Wright (1998), some advantages of the PSSDB system can be listed as below:

i. PSSDB is relatively very light as evidenced in Table 1 below:

Table 1: Weight of floor panel with varying dry board thicknesses

Thickness of Profiled Steel Sheet, Peva 45 (mm)	Thickness of Dry Board, Cemboard (mm)	Weight of 1 m x 2.4 m PSSDB panel (kg)
0.8	16	67.2
	18	73.2
	20	79.2

ii. The overall span to depth ratio obtained from previous investigation (Wright et al., 1989 and Wan Badaruzzaman and Evans, 1994) is 30 in comparison to one of approximately 16 for the traditional timber floor. It was shown that the PSSDB system could be designed to be 100 mm less deep than the traditional timber joist flooring system for a 4 m span floor carrying domestic loading.

iii. The construction procedure is simple. It doesn't require temporary formwork or propping. Therefore, it can be erected quickly by unskilled labour, hence cost saving.

iv. The system is easily transportable due to its lightweight. It can be stacked on top of each other during transportation.

v. Renovation work involving PSSDB panels is much easier to handle.

vi. For roofing system, it will posses a significant advantage of doing away with the internal bracing of normal roof truss construction and therefore creating additional living space.

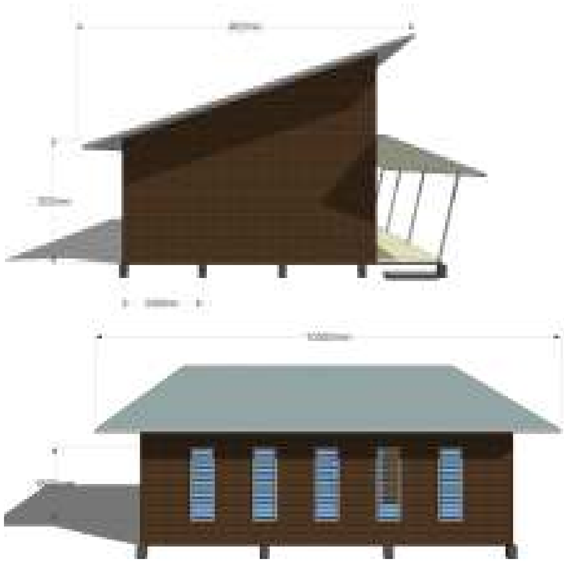
Most importantly, according to Badir & Razali (1999), this system falls under the concept of Industrialised Building System (IBS). The IBS is a methodology whereby the local construction industry is driven and encouraged towards the production and utilisation of pre-fabricated and mass produced building components off-sites in factories or controlled environment, to be transported and installed rapidly at the sites (Rahmadi et al. 2002). In terms of the environmental aspects, the PSSDB system is environmentally friendly as there is no wastage of construction materials. The panels could also be insulated to make them sound and heat proof.

3. THE SCHOOL CLASSROOM MODULES

The school classroom modules shown below (Figure 2) has been built based on PSSDB IBS and has been implemented for the first time at Sekolah Kebangsaan Telok Mas, Melaka, Malaysia. The total area of the each classroom module is approximately 105 m^2.

a. 3D view

b. Front elevation



c. Side elevation d. Rear elevation

Figure 2: Classroom modules

Three types of structural panel members utilising the PSSDB system for the modules are the floor, wall and roof panels. The materials used for the modules are listed in detail in Table 2.

Table 2: Details of the individual panel materials

Structure Panel	**Profiled steel sheet**		**Dry board**		**Connectors**	
	Type	Thickness (mm)	Type	Thickness (mm)	Type	Length (mm)
Floor	Peva 45	0.8	Cemboard	18	MK self drilling screws	32
Wall	Cliplock CL660	0.48	Prima*flex*	6 (inner) and 9 (outer)	Powerdrive DX-RW	25
Roof	Cliplock CL660	0.48	Prima*flex*	9	Powerdrive DX-RW	25

3.1 Floor

The floor panel is constructed out of a single skin Cemboard (dry board) connected to Peva 45 (profiled steel sheet). Cemboard conveniently forms the flat walking surface of the floor. The panel thickness is only about 65 mm which is much less than that of the typical concrete slab. The panel is also light enough to be lifted by two persons and can be stacked and delivered to the construction site with ease. This is especially beneficial for construction in remote areas where the basic infrastructure is limited and inaccessible to the use of crane and other heavy machineries. The floor panel size is 2400 mm x 1000 mm with screw spacing of 200 mm and is designed as simply supported. Figure 3 below shows a typical cross section of PSSDB floor panel.

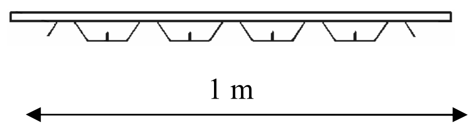


Figure 3: The cross section of a floor panel

Figure 4: Two workers lifting a 2.4 m PSSDB floor panel

3.2 Wall

The wall panel is constructed out of a double skin Prima*flex* (dry board) attached to a central core of CL660 (profiled steel sheet). The width of the wall panel is 660 mm. Figure 5 below shows a typical PSSDB wall panel with window opening. The lengths (heights) are however varied according to the tapered height of the wall.

Figure 5: Double skin wall panel with window openings

3.2 Roof

Based on the original concept of the system, the application of the PSSDB system has been extended to form a new concept of roofing system. The new approach will eliminate the roof trusses normally required in traditional roof structures. There are many advantages of the PSSDB roof system when compared to traditional forms of pitched roof structures in small and medium sized buildings which normally would involve the use of either a purlin and rafter or a trussed rafter system. This clearly arises due the load bearing capacity of the PSSDB system and due to it is made of more durable materials.

The roof system was designed to cater for a dead load of 0.31 kN/m^2 and an imposed load of 0.25 kN/m^2. Two sizes of panels were involved; 750 mm wide x 2000 mm length (14 nos) and 750 mm wide x 4000 mm length (28 nos) and the screw spacing is 100 mm. Table 2 shows the details of the individual components and Figure 6 shows the PSSDB panel system for the roof.

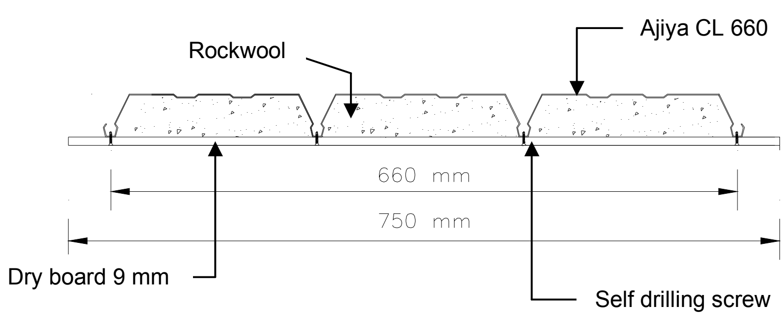


Figure 6(a). Reversed position of proposed PSSDB roof panel

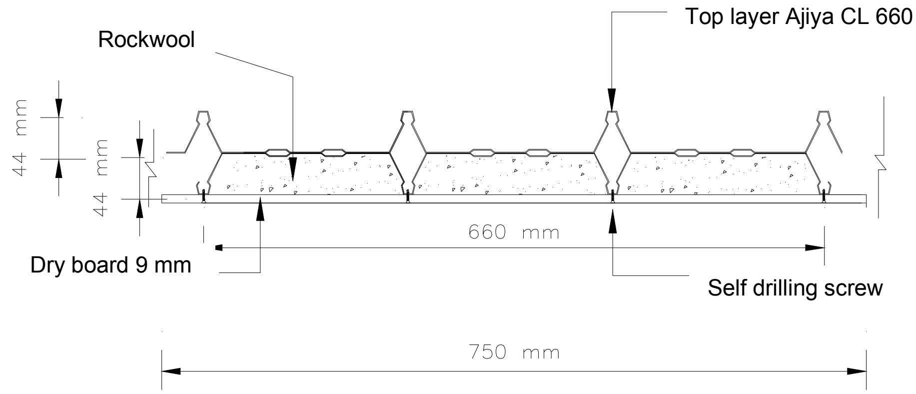


Figure 6(b) Proposed PSSDB roof panel

4. PREPARATION AND CONSTRUCTION PROCESS

The site was cleared and prepared prior to the beginning of the installation of the modules. The footing was constructed out of normal reinforced concrete. All modules were prefabricated in the factory as shown in Figure 7.

The erection process started with the placement of the floor after construction of the floor beam has been completed. After all the floor panels have been placed, the wall panels are installed one after another. Finally, the roof panels were installed into position. Figures 8 (a-d) show the processes of erection of the modules, while Figure 9 shows the completed modules. The whole construction process was completed in a timely manner with minimal material wastage, less site materials, neater and safer site condition and better quality control.

Figure 7. Stacks of PSSDB panels at the construction site

Figure 8(a). Construction of footing

Figure 8(b). Erection of floor panel

Figure 8(c). The propped wall and laid floor panels

Figure 8(d). Erection of roof panels

Figure 9: Completed classroom modules

5. CONCLUSION

This paper has described the application of Profiled Steel Sheet Dry Board (PSSDB) system as a structural component in constructing innovative lightweight composite school classroom modules. The system has many advantages. It was successfully implemented in two school classroom modules at Sekolah Kebangsaan Telok Mas, Melaka, Malaysia. The described application manifests the potential of the PSSDB system to be implemented as a complete IBS in the construction of buildings.

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